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PLANT PROPAGATION WITH ARTIFICIAL LIGHT

Light Requirements of Plants

Plants cannot survive without light of adequate intensity for photosynthesis. In the field and garden or in the greenhouse this high-intensity light is obtained from the sun, which often provides an illumination as high as 10,000 foot-candles. In the average home the intensity of natural light even on the window sills is usually too low for growth of many kinds of plants. However, plants can be grown quite successfully with artificial light in complete absence of sunlight.

Flowering of many kinds of plants is controlled by the relative length of the daily light and dark periods. This phenomenon is called photoperiodism. Poinsettia, certain varieties of chrysanthemum, morning-glory, cocklebur, and lambsquarters are called short-day plants, because they flower only when the days are short and the nights are long. Certain varieties of spinach, beet, barley, and tuberous-rooted begonia are examples of long-day plants, which flower only when the days are long and the nights are short. Many other kinds of plants flower with a wide range of daylengths; but some flower sooner on a schedule of short days, others on a schedule of long ones. Scarlet sage, variety America, flowers quickly with short days but eventually flowers with long ones. Many varieties of petunia flower most rapidly on a schedule of long days but finally flower with daylengths as short as 8 hours.

Many other features of plant growth are regulated by the seasonal changes in daylength. Bulbing and tuber formation, for example, are controlled by daylength. Tuberous-rooted begonia, which grows vigorously and flowers with long days, produces tubers and becomes dormant with short days. The preparation of woody plants for the coming of winter is another plant response regulated by photoperiod.

The seasonally changing daylength is the only reliably consistent feature of the natural environment. The gradually lengthening nights of late summer and early fall induce many kinds of plants to form overwintering buds and otherwise prepare for winter's onset. Even in the warm greenhouse many woody plants stop elongation of stems, produce terminal buds, and "harden off" when the nights begin to lengthen in the autumn. However, if artificial light is used to shorten the nights, some woody plants in the warm greenhouse continue growing during the naturally short days of winter and the equivalent of several years' "field" growth is often obtained in only 1 year.

Growth and differentiation of plants are to a large degree controlled by light. Plants grown in total darkness have very long internodes and small leaves, and are yellow because no chlorophyll is formed. If the dark-grown plants are exposed to weak light for a minute or two each day, the plants have shorter internodes and normal-size leaves, although they may still be yellow and without visible chlorophyll. Daily exposures of dark-grown plants to light of higher intensities or for longer durations may not change the size of the leaves or internodes of the plants from that obtained with brief exposures to light of low intensity. The plants turn green, however, at the higher light energies owing to chlorophyll formation, but this reponse is a photochemical reaction other than the one controlling form in plants.

The formative effects of light come about through a red, far-red photo-reversible reaction that also controls flowering of photoperiodically sensitive plants, germination of light-sensitive seeds, and many other plant responses. This photoreaction is discussed in more detail in ARS Special Report 22-64 entitled "Plant Light-Growth Discoveries."[1] Red is the most efficient portion of the spectrum for inhibiting stem elongation and promoting leaf expansion. A far-red irradiation immediately following the red reverses the potential effect of the red irradiation, and the stems become long.

Far red at the close of each light period permits stems of light-grown plants to elongate. If the far red is followed by a brief exposure to red, the effect of the far red is reversed and elongation is inhibited.

Kinds of Artificial Light

The two types of lamps commonly used for plant growth differ greatly in the proportions of red and far red in their white light. Light from ordinary incandescent-filament lamps contains large amounts of both red and far red. Sunlight, although usually much more intense, contains about the same relative proportions of red and far-red energy as does incandescent-filament light. Light from fluorescent lamps, on the other hand, is high in red and extremely low in far red. If more far red is wanted in a propagating chamber lighted with fluorescent tubes, it can be obtained by adding some incandescent lamps.

Both incandescent and fluorescent lamps have a useful place in artificially lighted chambers. For example, fluorescent lamps are useful for fulfilling high-intensity requirements. On the other hand, incandescent lamps have proved more effective in speeding the flowering of long-day plants and promoting swifter growth in woody and foliage plants.

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[1] Obtainable free from Information Division, Agricultural Research Service, Washington 25, D. C.

A practical general source of artificial light for plant growth and indoor propagation is the fluorescent lamp. These lamps supply an intensity and quality of light adequate for photosynthesis without excessive heat and are available in various lengths, wattages, and colors. They are usually operated on one- or two-lamp ballasts, which maintain the proper current and provide the starting voltage. Prewired lamps and ballasts of several sizes and types are available as commercial luminaries or channels.

Many kinds of plants can be propagated and grown satisfactorily with only two 40-watt fluorescent lamps. As the lamps themselves are relatively cool, the plants may be placed quite close to them, where light intensity is the greatest, without danger of excessive heat.

If the daylength is to be shortened, plants must be put into complete darkness at the close of a particular photoperiod. They are often sensitive to very low light intensities, so it is important that all light be excluded. Daylength control can be facilitated and made more exact if an electric time switch is available to turn the lights on and off at desired times.

Propagation Chambers

Several kinds of lighted plant-propagation chambers are commercially available. However, the following plans are given for gardeners who may want to construct their own propagating equipment.

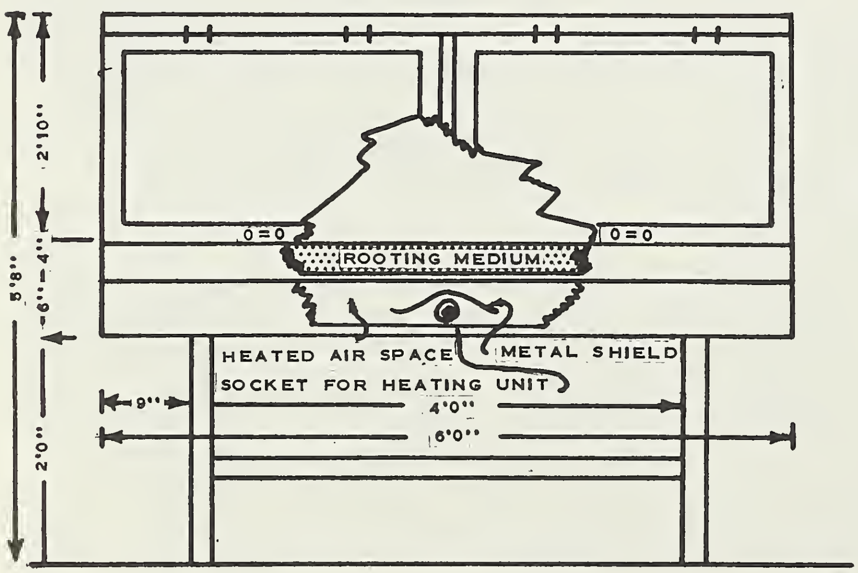
A case 6 feet long, 3 feet wide, and 3 feet high is suggested for use with two 40-watt tubes, although some of the space at the ends will not be usable for seedlings that have a high light requirement. A width of 2 feet may be advisable for portability through the doors of houses. Two doors hinged at the top are provided for the front of the case. The suggested dimensions can be changed to accommodate fluorescent lamps of other sizes.

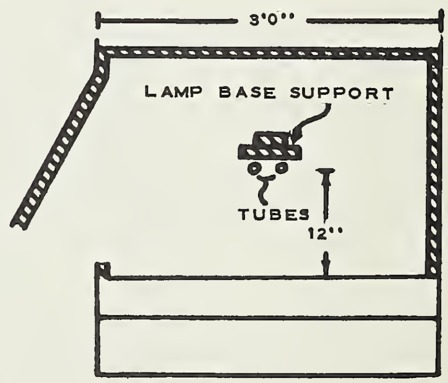
To economize on electric current and to prevent excessive condensation, which depletes atmospheric moisture, high-insulating material should be used for the walls of the case. The skeleton of the box may be made of metal or of woods resistant to warping and decay, such as 1-by 2-inch pieces of redwood or cypress. Some of the glass-substitute materials have been satisfactory as coverings in locations away from direct sunlight and where rather high temperatures make insulation unimportant. Covering the glass substitute with manila paper eliminates condensation and thereby maintains a higher humidity.

In some locations the base will necessarily be made watertight, with some arrangement for catching drainage water from the rooting medium. Under some conditions no special provision for heating the case will be needed.

If soil-heating cables are used, the rooting medium may be placed above them to a depth of at least 4 inches. These cables should be used with special soil-heating thermostats. These have been standard equipment in hotbeds for years and can be obtained from many dealers in seeds and garden supplies. To insure safety, the wiring of the heating elements and the fluorescent lamps should be done by a qualified person.

An alternative method of supplying "bottom heat" for the rooting medium is illustrated in the following diagram, which shows the use of a socket heater or a lamp in an air space below the rooting medium. Small sealed heating units in the range of 75 to 150 watts can be obtained with bases fitting standard lamp sockets. A single unit should be adequate in a well-insulated case in most locations, but with a good thermostat there is no disadvantage in having the heating unit larger than necessary. Two ordinary tungsten-filament lamps connected in series may be used, but none of their light should reach the plants. The socket for the heater should be mounted on one side wall of the case, below the trays of flats that contain the rooting medium. A small metal shield above the socket will aid in preventing the entrance of drainage water. With this heating arrangement, an inexpensive air thermostat, such as those used in chicken brooders, may be used. Some have found that placing pans of water in the air space beneath the rooting medium aids in maintaining a high humidity. This type of heating may be used with the rooting medium placed in removable trays snugly fitted together to rest on brackets.





Propagation by Seed

The germination of some seeds is controlled by light. The photo-reversible reaction that regulates seed germination also controls flowering, stem elongation, and other phases of plant development. Seedsmen customarily recommend little or no soil cover for many kinds of seeds, presumably because the seedlings are too small or weak to penetrate the soil cover. Actually, the seeds need light for germination and covering them with soil puts them in the dark.

Good results with seed germination are obtained by using sphagnum moss in accordance with directions given in U. S. Department of Agriculture Farmers' Bulletin No. 2085, entitled "Sphagnum Moss for Plant Propagation."[2] Other publications giving details of seed sowing and the early care of seedlings in flats are USDA Farmers' Bulletin No. 1171 entitled "Growing Annual Flowering Plants," and USDA Home and Garden Bulletin No. 9 entitled "Suburban and Farm Vegetable Gardens."[3]

During the period of germination, cover the seed pan or flat with a pane of glass or clear plastic to reduce surface evaporation. Unless seedlings are pricked off into a soil mixture at an early stage, dilute nutrient solutions should be applied occasionally to plants in either sphagnum moss or vermiculite, to keep them in active growth. A satisfactory solution may be made by stirring 3 to 6 teaspoonfuls of the average mixed complete garden fertilizer in 1 gallon of water. The insoluble residue may be discarded.

To start seedlings, a fixture carrying at least two 40-watt fluorescent lamps is recommended. With a good reflector, light intensities of 500 to 800 foot-candles prevail in the area within 6 inches of the lamps. This is about the minimum for most kinds of seedlings, but with care in providing correct temperatures satisfactory seedlings can be produced.

The best seedlings are produced when they are grown close to the lamps, since light is most intense at that level and heat is not excessive even when the seedlings almost touch the lamps. As the seedlings grow and elongate, the pans or flats may be lowered as needed. Preferably, seedlings should be kept within 1 foot of the lamps. The intensity of light from fluorescent lamps is greatest near the center of the tubes and the seedlings may be advantageously arranged so that seedlings such as pansies, which require less light, are placed near the ends of the tubes.

2/ Obtainable for 10¢ from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

3/ Obtainable free from Office of Information, U. S. Department of Agriculture, Washington 25, D. C.

Home gardeners starting their own seedlings will get better transplants by controlling the amount and kind of light the plants receive. Most commonly grown annuals flower best on long days. Among these are petunia, aster, bachelor-button, coreopsis, forget-me-not, phlox, rudbeckia, salpiglossis, scabiosa, snapdragon, and verbena. Germinating the seeds and growing the seedlings of these kinds with fluorescent light on a 10-hour-day schedule delays flowering slightly but results in compact short-stemmed plants for outdoors in about 6 to 8 weeks after the seeds are planted.

Some commonly grown short-day garden annuals are cockscomb, cosmos, globe-amaranth, marigold, salvia, and zinnia. On 10-hour photoperiods these kinds will be accelerated to flower prematurely on relatively short-stemmed plants. Seedling growth of short-day plants (p. 1) is enhanced by growing them on long days (for example, 16 hours) in fluorescent light. This daylength and light source in general delays flowering, stimulates vegetative growth, and improves transplant form.

When only one chamber is available for both kinds of plants, start the long-day kinds on the 10-hour daylength in fluorescent light as recommended. Seeds of the short-day kinds should be planted at a somewhat later date. An alternative method would be to grow both kinds on a 16-hour daylength and after 10 hours of the fluorescent light cover the short-day flowering kinds to give them complete darkness within the lighted chamber.

If the temperature within the chamber is maintained in the range of 60° to 70° F., excellent seedlings of the many different kinds of ornamental annuals and vegetables can be grown with only two 40-watt fluorescent lamps. Incandescent lamps should not be used as a light source to start seedlings because the heat and far-red light from this kind of lamp will cause the plants to be long stemmed and spindly.

Propagation by Cuttings

It is known that the duration of light influences the rooting of woody-plant cuttings, both directly and through its influence on the stock plant.

The daylength to which some kinds of stock plants are exposed exerts a marked effect on the rooting ability of cuttings subsequently made from them. The woody plant weigela is an example. If grown continuously on long days (14 hours or longer) weigela grows actively and flowers. Softwood cuttings taken anytime root readily in similar-length long days. If grown on short days of 12 hours or less, the plants stop growing and are difficult to propagate.

The herbaceous chrysanthemum is another example. Cuttings should be taken only from vegetative plants. The stock plants are kept vegetative by growing them either on the natural long days of summer or on artificially lengthened days of other seasons. The cuttings are then rooted on a schedule of long days to prevent premature flowering. The critical length of day to prevent flowering depends upon the variety; in most cases it will exceed 15 hours.

Experiments in the State Experiment Stations and U. S. Department of Agriculture have shown that cuttings of many kinds of woody plants root better when natural days are extended with incandescent light. Examples of such plants are abelia, dogwood, euonymus, willow, and certain varieties of boxwood, holly, magnolia, and rhododendron. There are instances where the artificial light was not particularly beneficial but in no case was it detrimental to rooting or growth. In general, natural days supplemented with incandescent light caused and increase in the speed and the extent of rooting as measured by the number and length of the roots produced. In some cases long day-length stimulated earlier bud break and shoot growth of cuttings.

The studies of the rooting of woody plants have mainly used incandescent light as a supplement to natural daylength. Since the rooting responses to neither incandescent nor fluorescent light as sole sources have been thoroughly tested, a combination of fluorescent and incandescent light should be used to propagate woody plants, if artificial light is to be used exclusively. For example, outlets for two incandescent lamps of 40 watts or more can be mounted near the ends of the fixture having two 40-watt fluorescent lamps. Care must be taken to avoid undesirably warm-air temperatures caused by the addition of the incandescent lamps to the chamber.

Coarse sand or medium-sized grades of either vermiculite or perlite are satisfactory rooting materials. Vermiculite and perlite, forms of minerals expanded at high temperatures, have exceptionally good moisture-holding properties and excellent aeration. These materials are available from dealers of building supplies. For acid-soil plants, such as azaleas, a mixture of 3 parts of peat to 1 part of vermiculite, perlite, or sand is desirable. About 4 inches of the medium is sufficient for most kinds of cuttings, and all rooting media should be thoroughly wetted before inserting any cuttings and kept moist during the rooting period.

Little or no ventilation is needed for cuttings, and high humidity is desirable. The temperature of the rooting medium is important; it should be adjusted by means of an accurate thermometer, the bulb of which is inserted to the same depth as the cuttings. Although plants differ in their preferences, the best rooting of many kinds of plants will be at temperatures near 70°F. in the rooting media. Additional general suggestions for the rooting and after-care of cuttings are found in USDA Home and Garden Bulletin No. 80 entitled "Home Propagation of Ornamental Trees and Shrubs." 4/

4/ Obtainable free from Office of Information, U. S. Department of Agriculture, Washington 25, D. C.

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